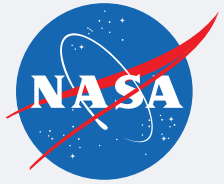
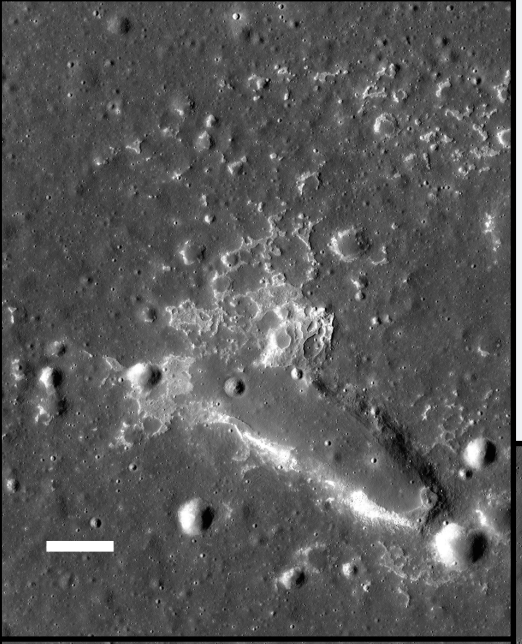


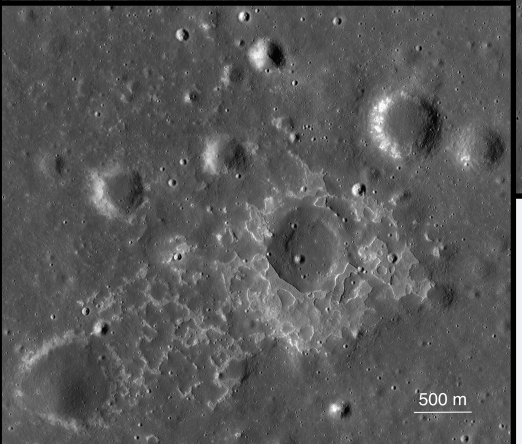
Low Thermal Inertia Volcanic Deposits on the Moon

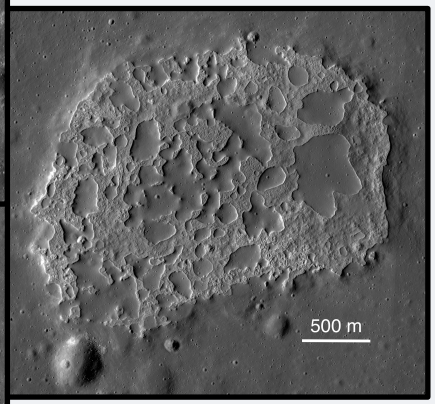
Catherine M. Elder[1], Paul O. Hayne[1], and Tim D. Glotch[2]

[1]Jet Propulsion Laboratory, California Institute of Technology; [2]Stony Brook University

Irregular mare patches







Pyroclastic deposits

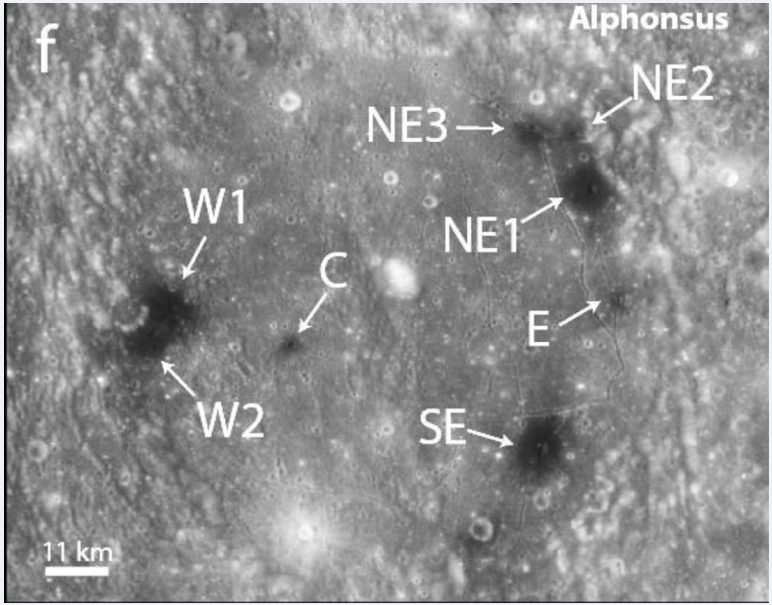
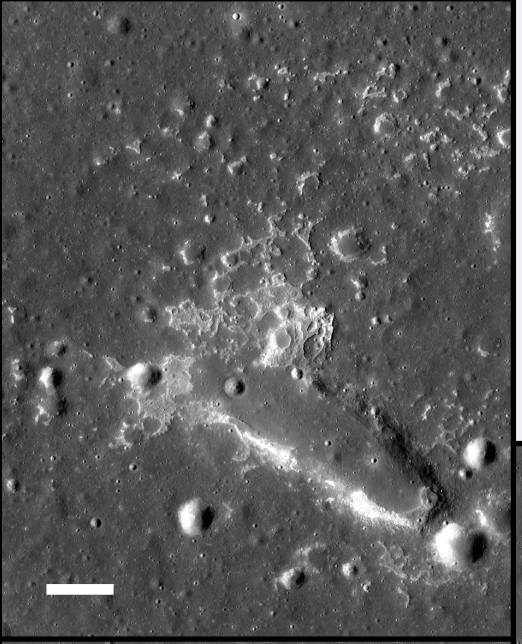
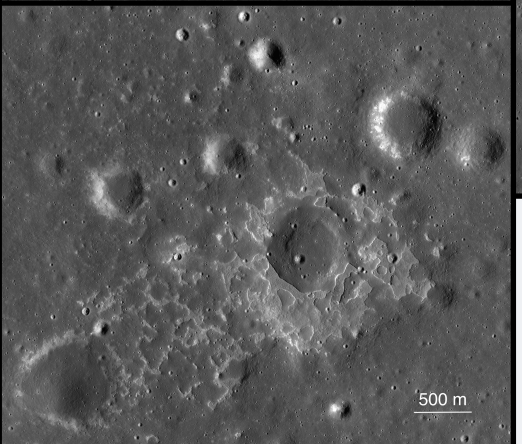
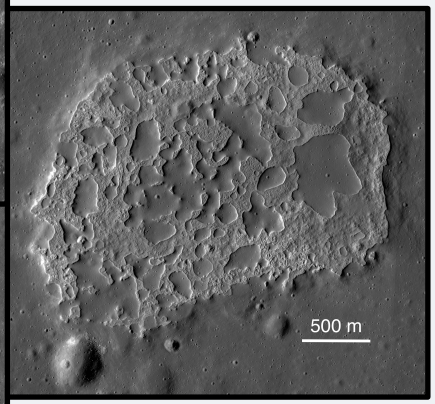


Figure credit: Trang et al. (2017)



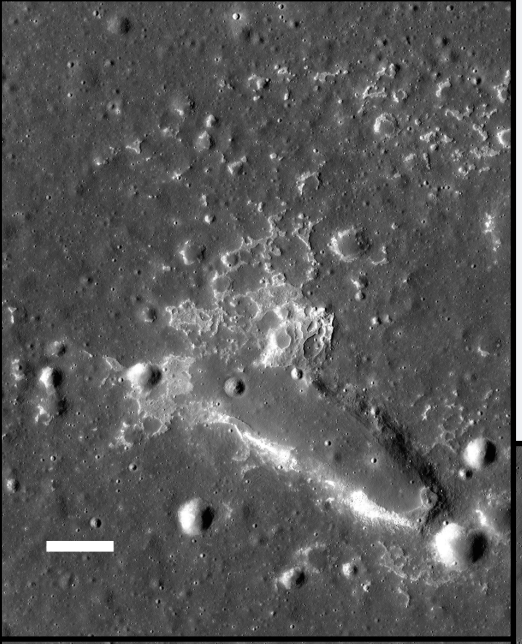


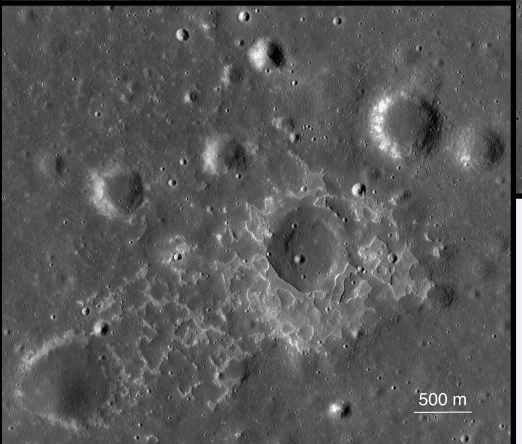
Irregular mare patches



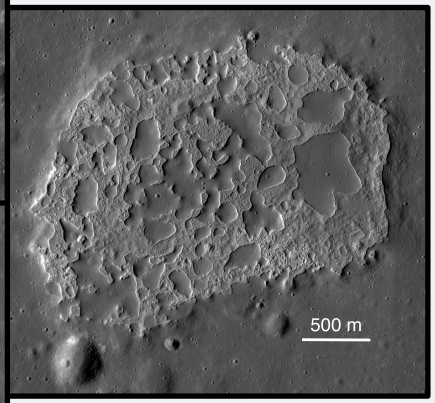
- Small 100 – 5000 m
- 70 identified
- Young? (controversial)
  - Crater counting
  - Optical maturity
  - Topographic relief

  → Inconsistent with thermal evolution models and other examples of lunar volcanism





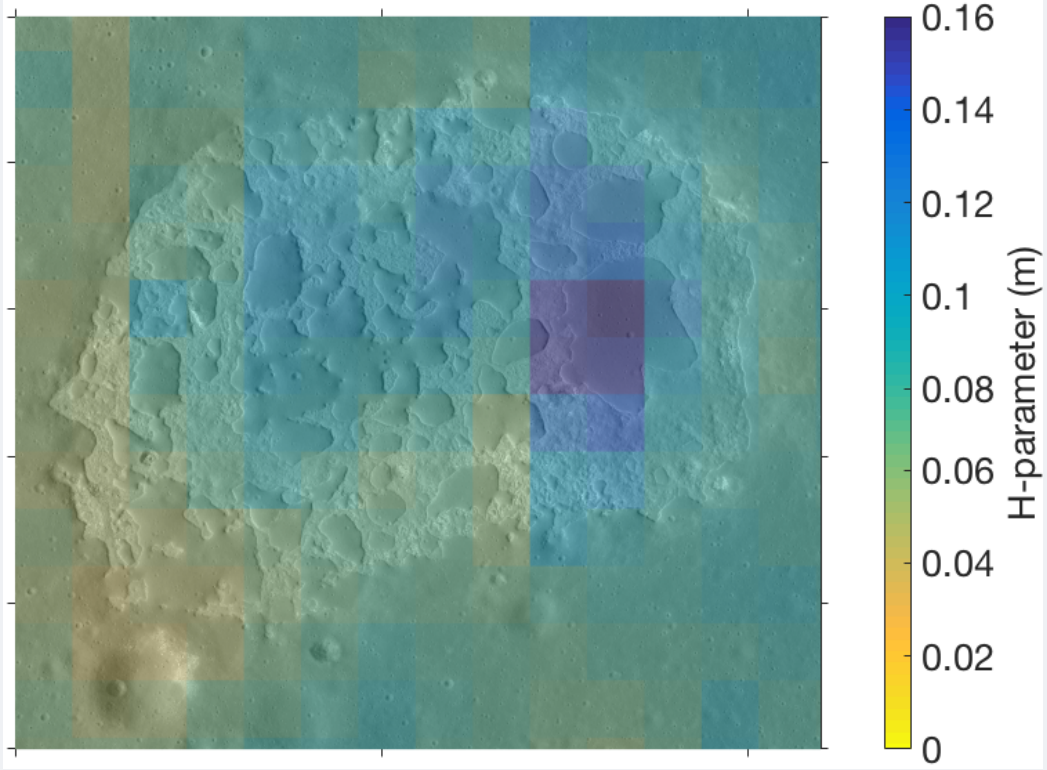
Irregular mare patches



- Caldera Collapse (El-Baz, 1973)
- Explosive outgassing (Schultz et al., 2006)
- Lava flow inflation (Garry et al., 2012)
- Pyroclastic eruptions (Carter et al., 2013)
- Regolith drainage (Qiao et al., 2016)
- Vesicular magmatic foam (Wilson et al., 2017)

Irregular Mare Patches

- Data from the Lunar Reconnaissance Orbiter (LRO) Diviner radiometer
- Ina has a low thermal inertia (Elder et al., 2017)
- Pyroclastic eruptions? Magmatic foam?



Pyroclastic Deposits

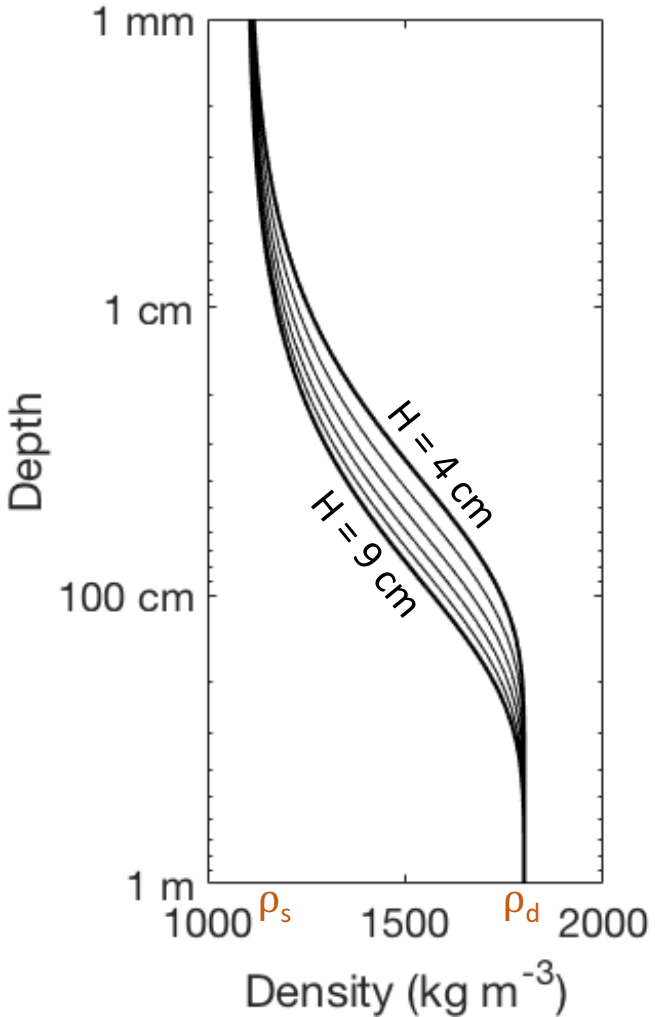
- Regional deposits (>2500 km^2):
  - formed through lava-fountain eruptions
  - composed of crystalline beads and/or glass beads
- Localized deposits (<2500 km^2):
  - formed through Vulcanian-style eruptions
  - incorporate a higher fraction of country rock
- Deposits of glass beads → lower thermal inertia than regolith
- Country rock would increase the thermal inertia

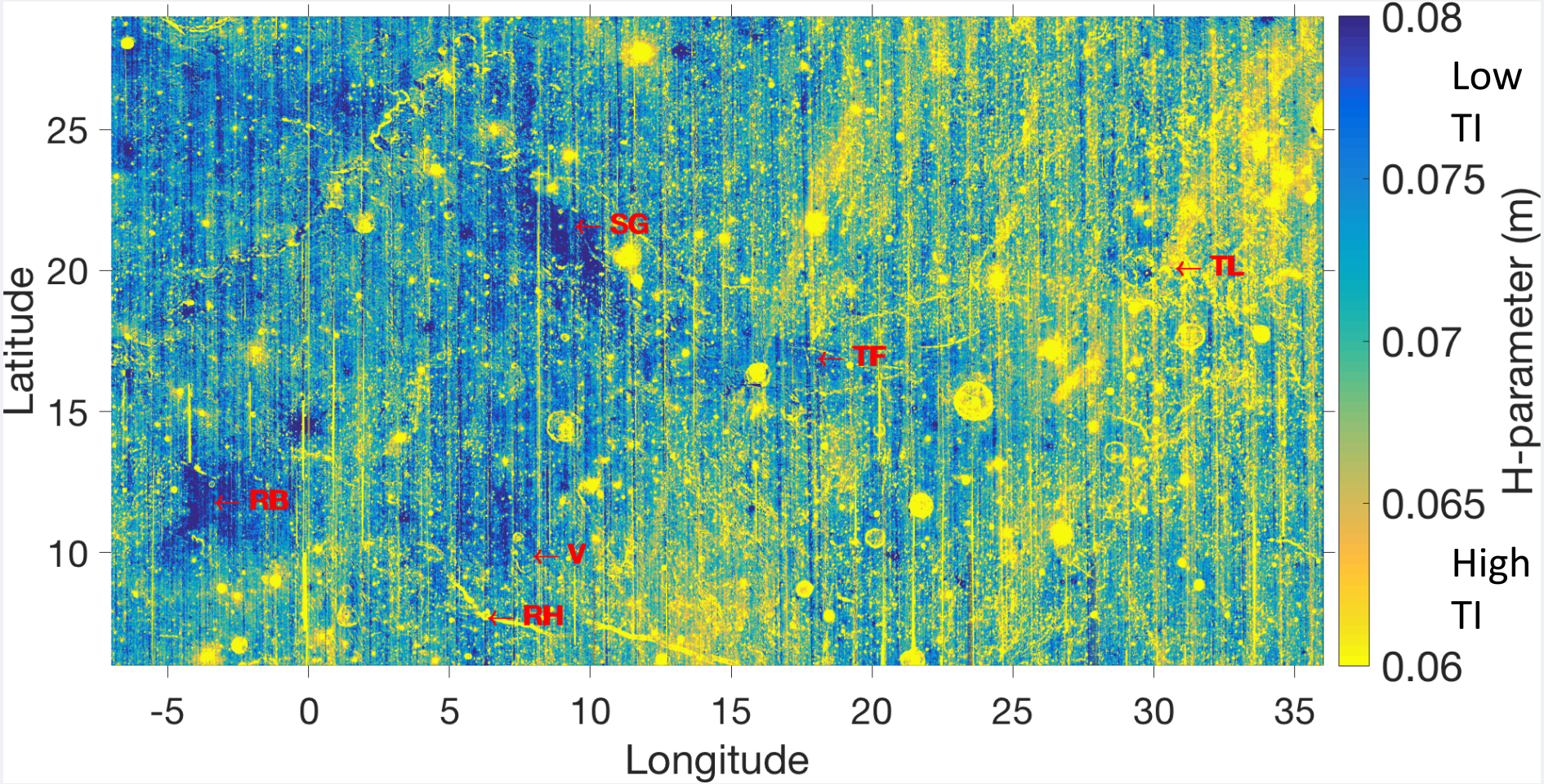
Methods

- Fit Diviner nighttime regolith temperature measurements from Bandfield et al. (2011)
- Temperatures exclude rocks >1 m
- Thermal inertia proportional to density
- Assume regolith density:

  $\rho(z) = \rho_d - (\rho_d - \rho_s)e^{-z/H}$
- Low H → high thermal inertia → more rocks / lower porosity

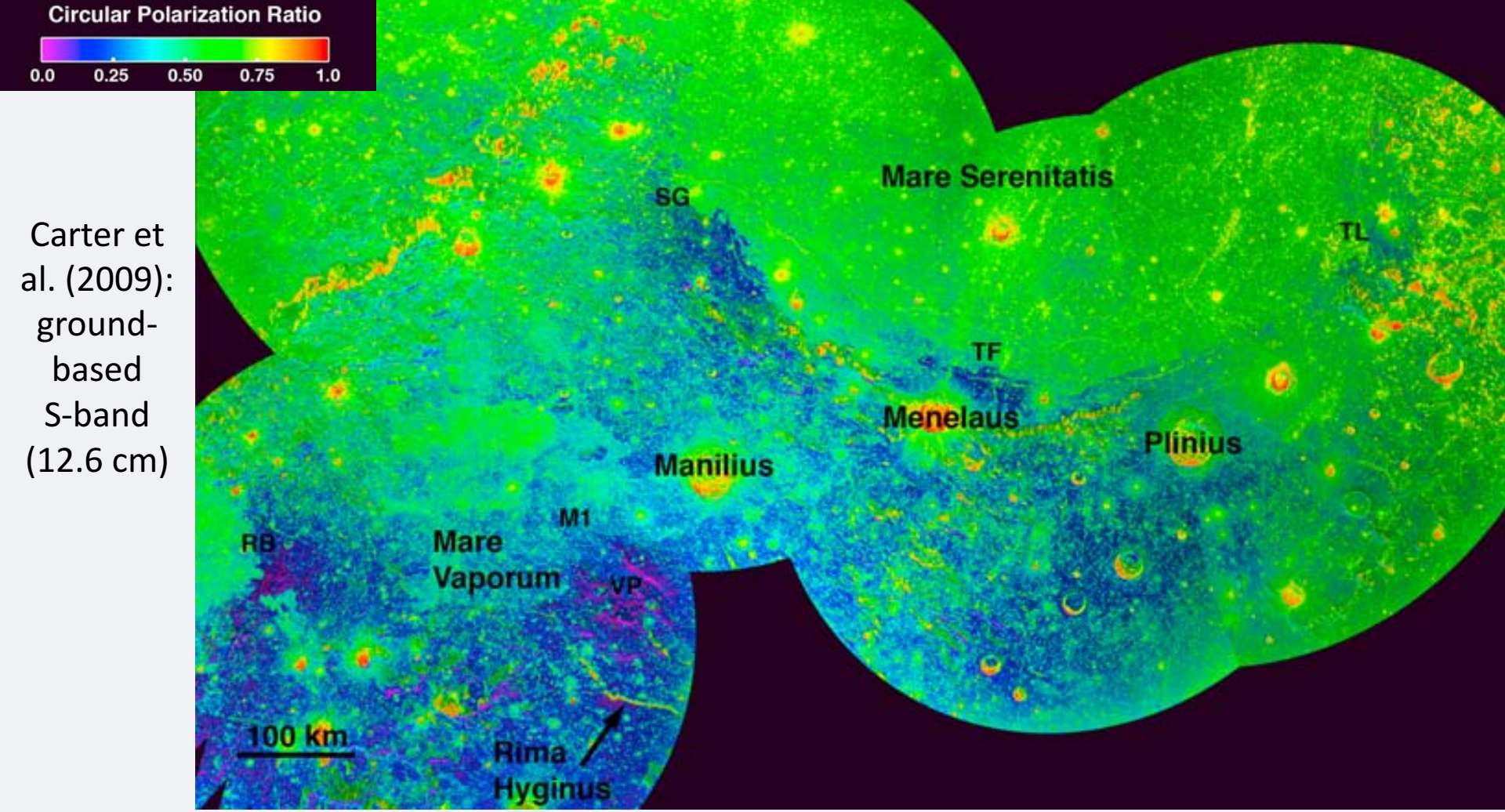
(Hayne et al. submitted)





Rima Bode (RB), Sulpicius Gallus (SG), Vaporum (V), Taurus-Littrow (TL), Tacquet Formation (TF), Rima Hyginus (RH)

Carter et al. (2009): ground-based S-band (12.6 cm)



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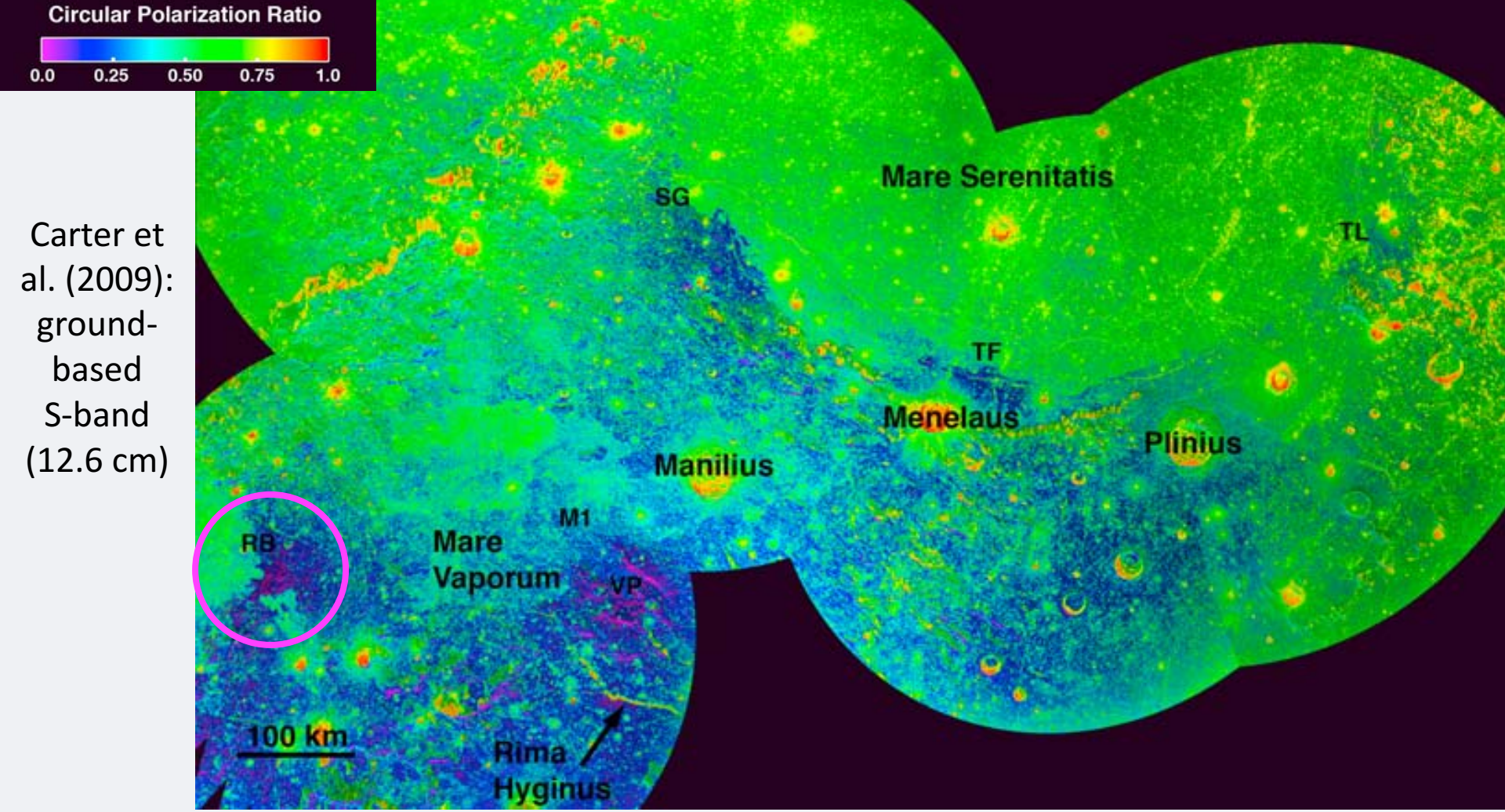

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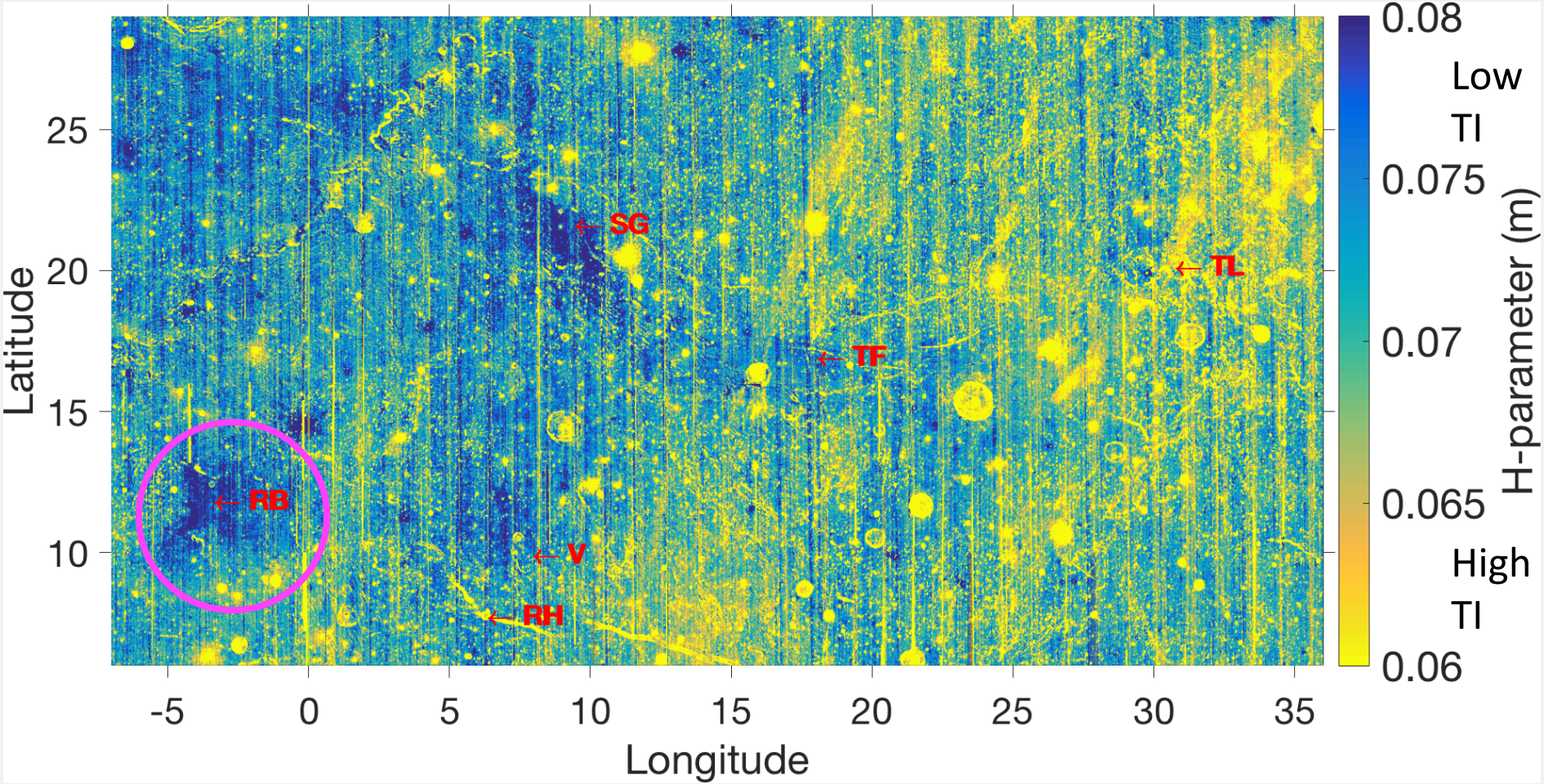

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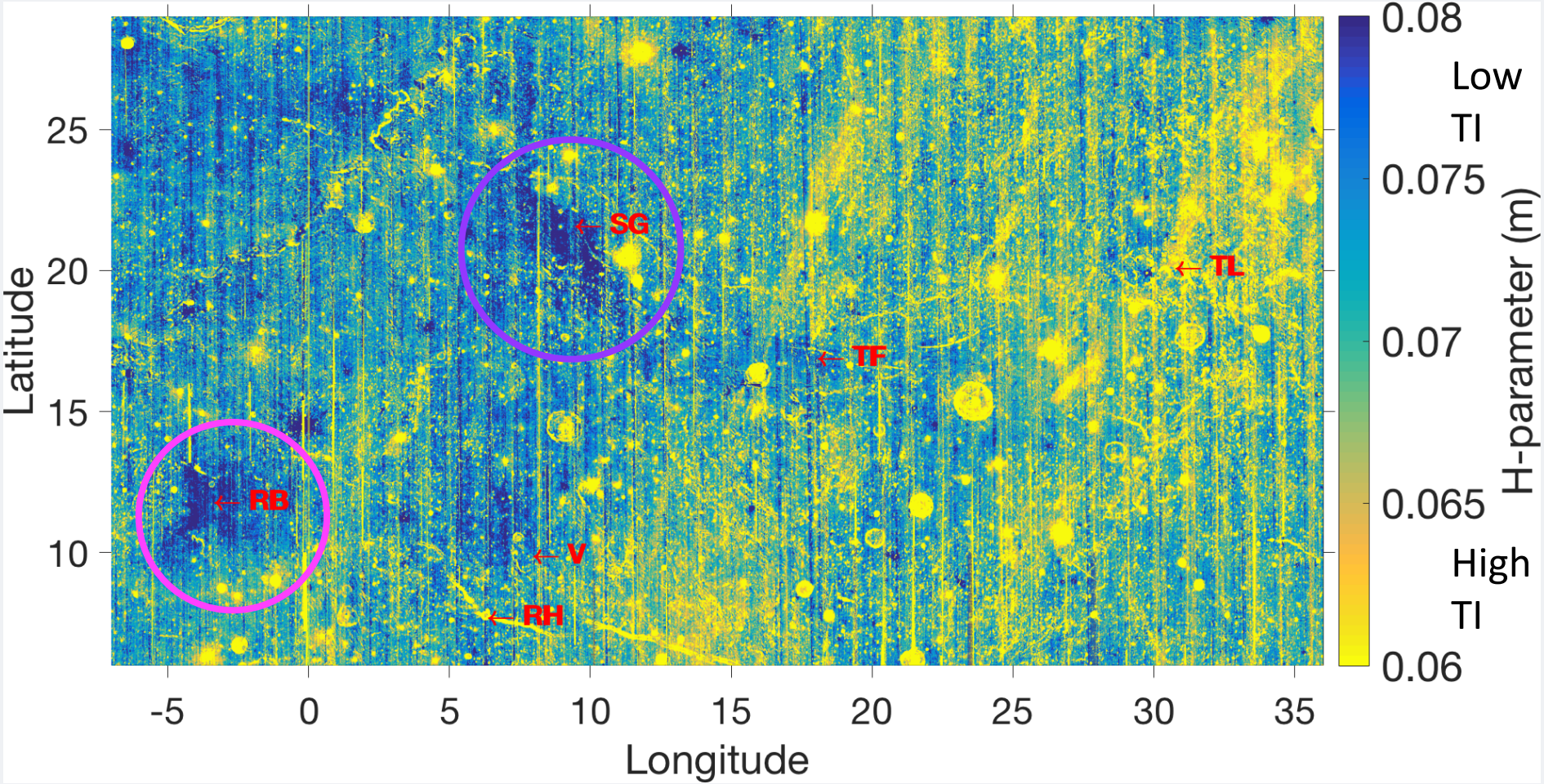

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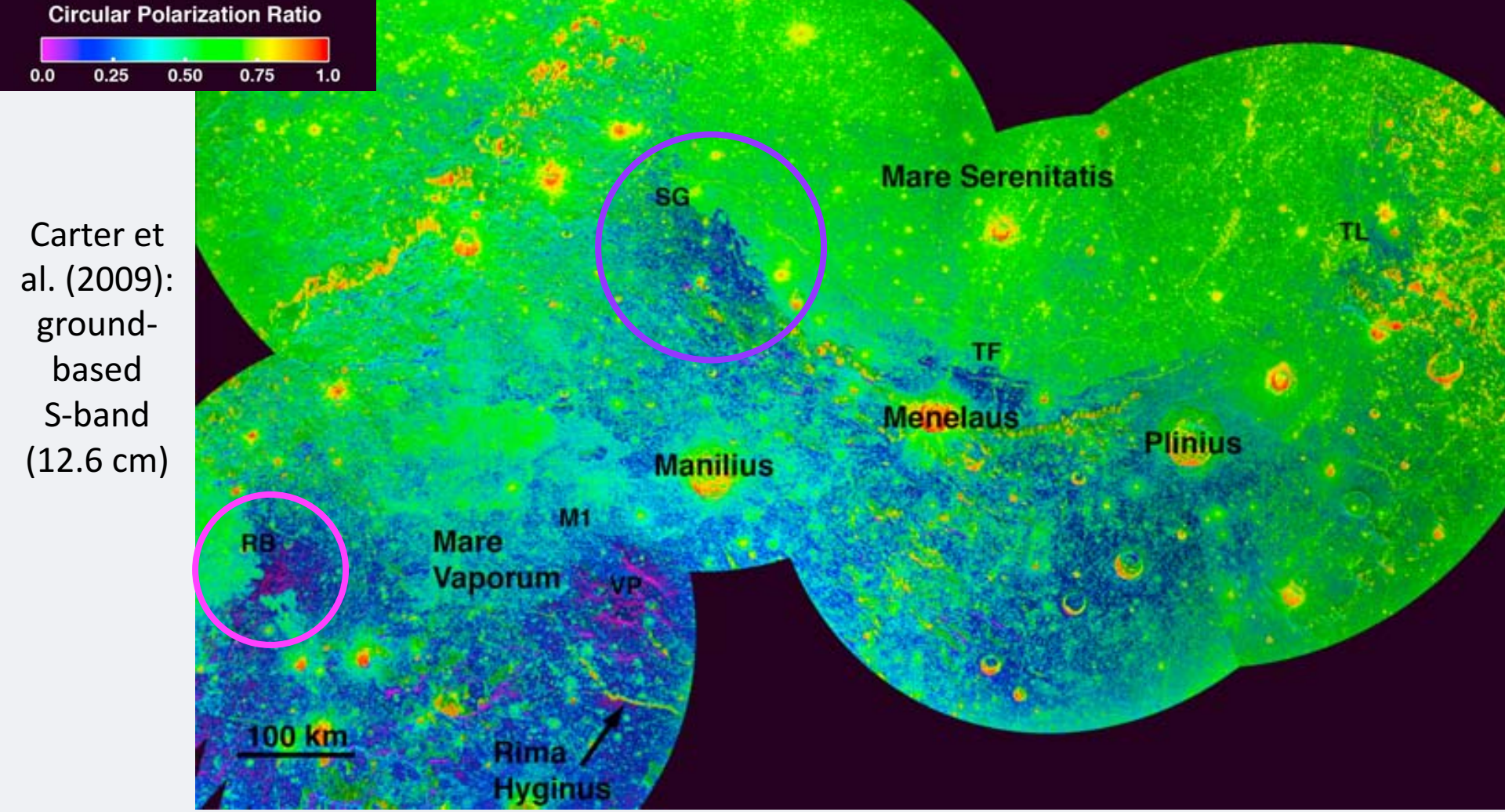

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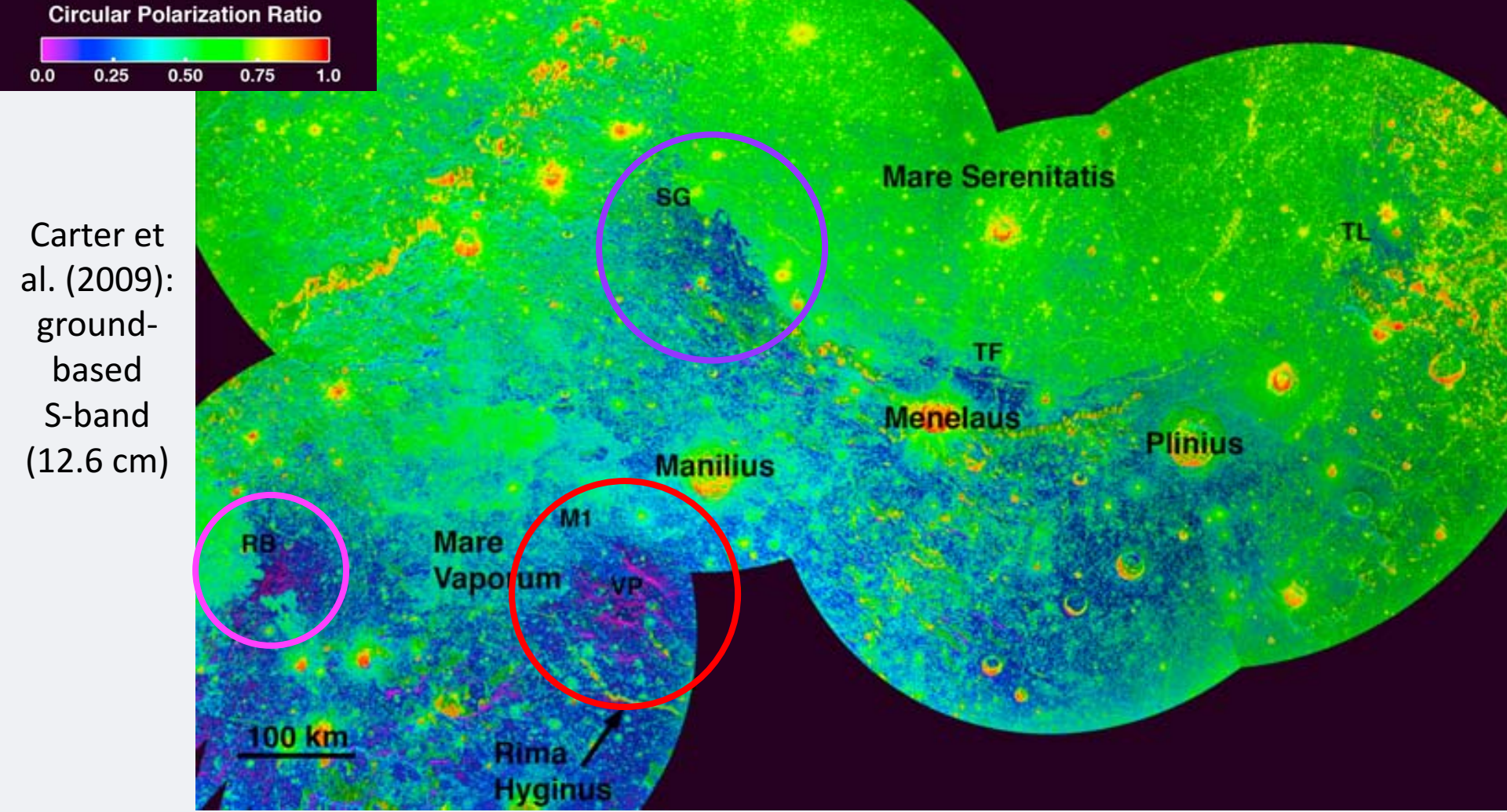

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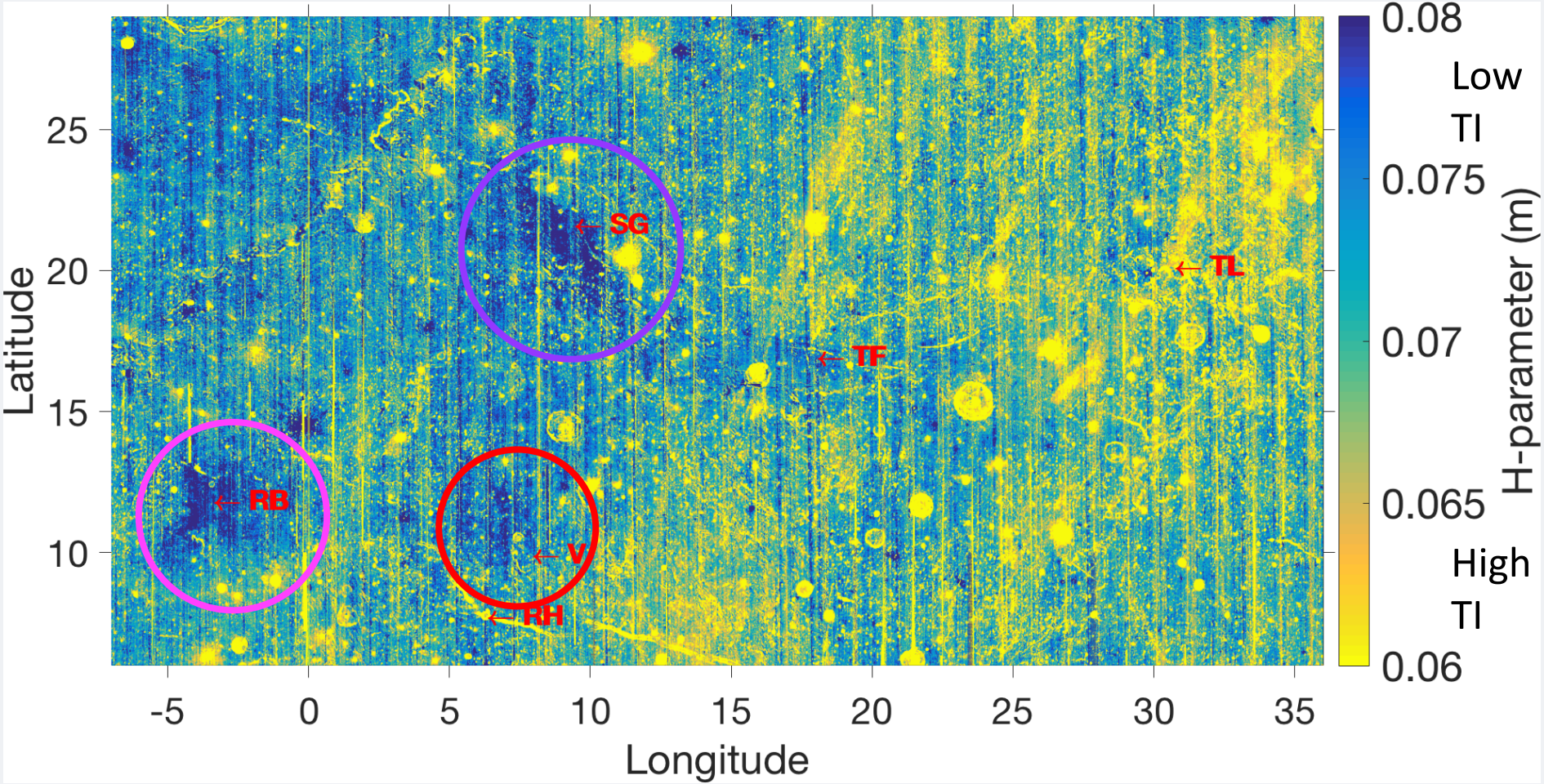

Rima Bode (RB), Sulpicius Gallus (SG), Vaporum (V), Taurus-Littrow (TL), Tacquet Formation (TF), Rima Hyginus (RH)

Localized Pyroclastic Deposits

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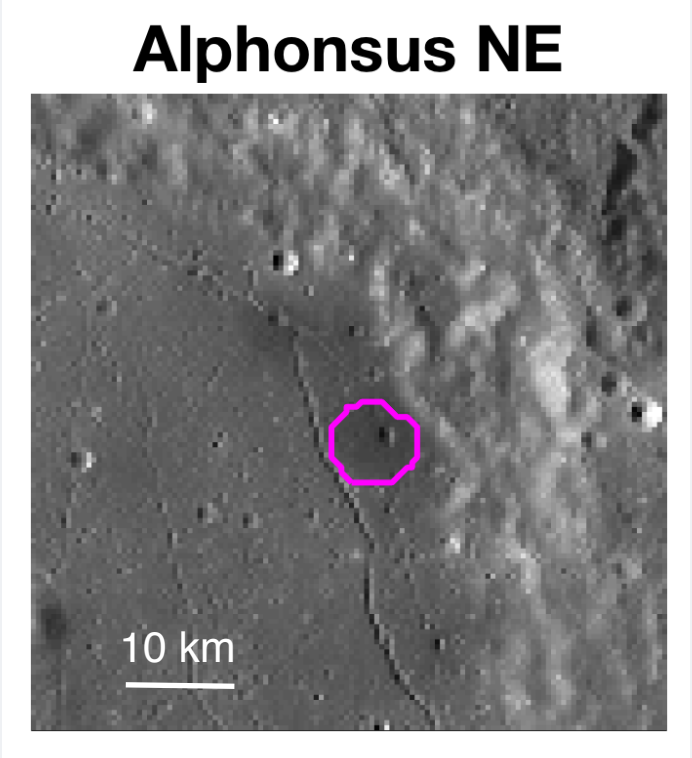
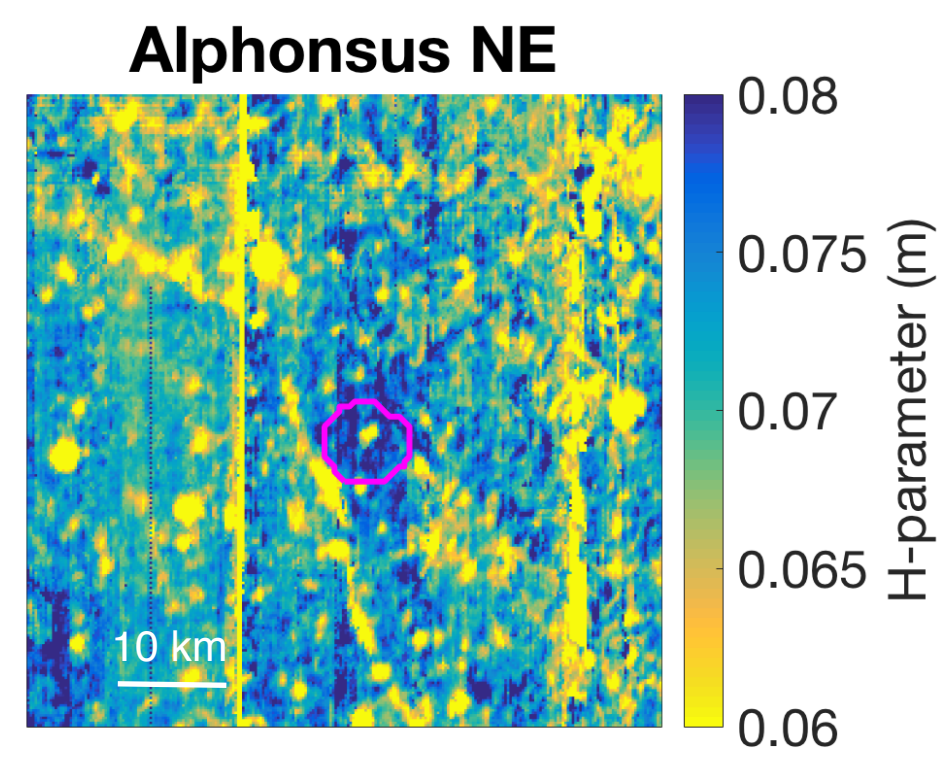
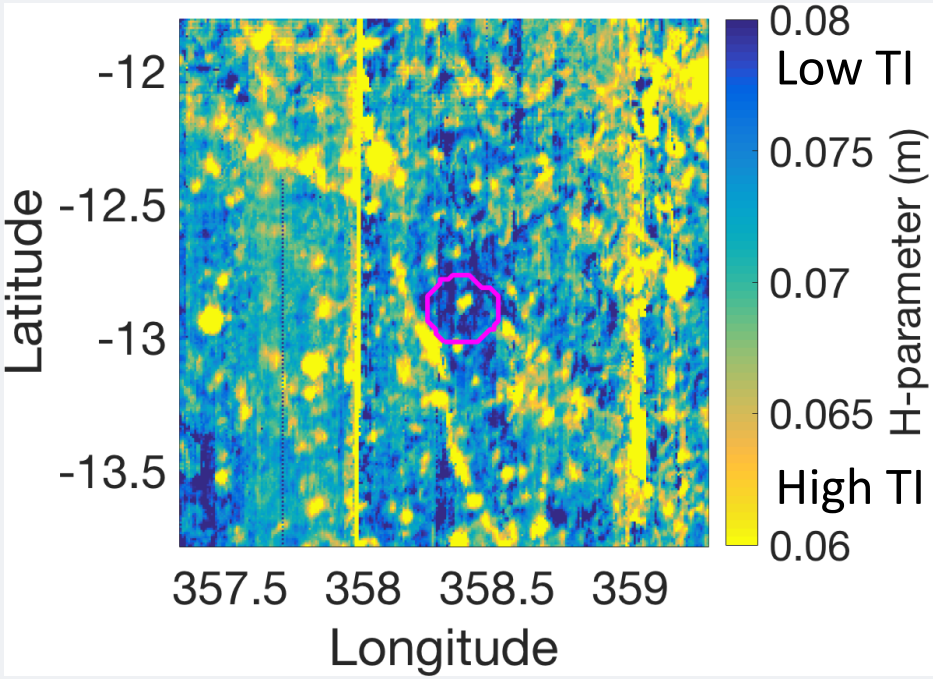
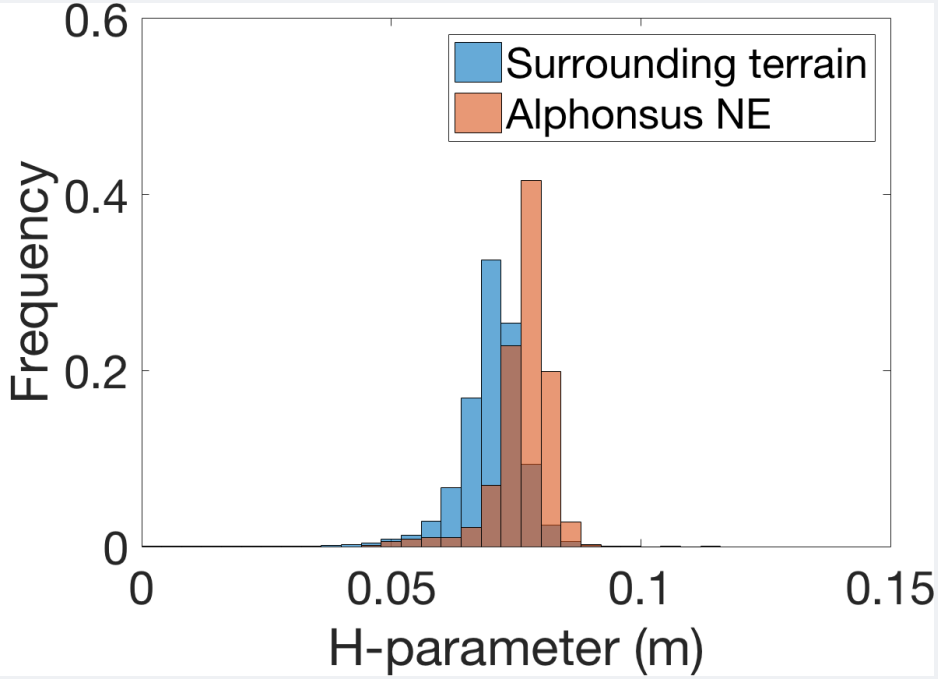


Localized Pyroclastic Deposits

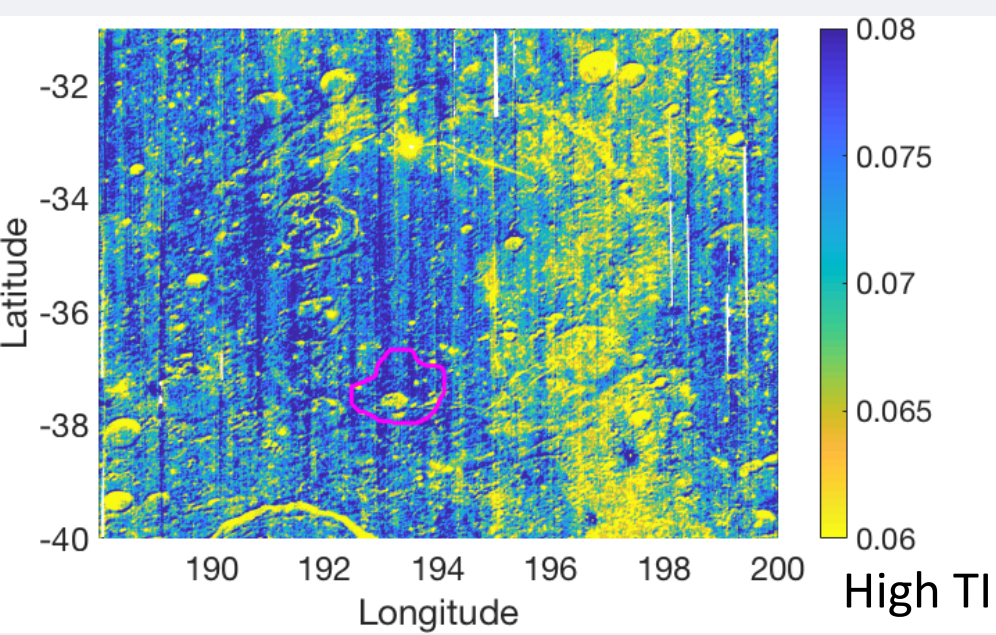


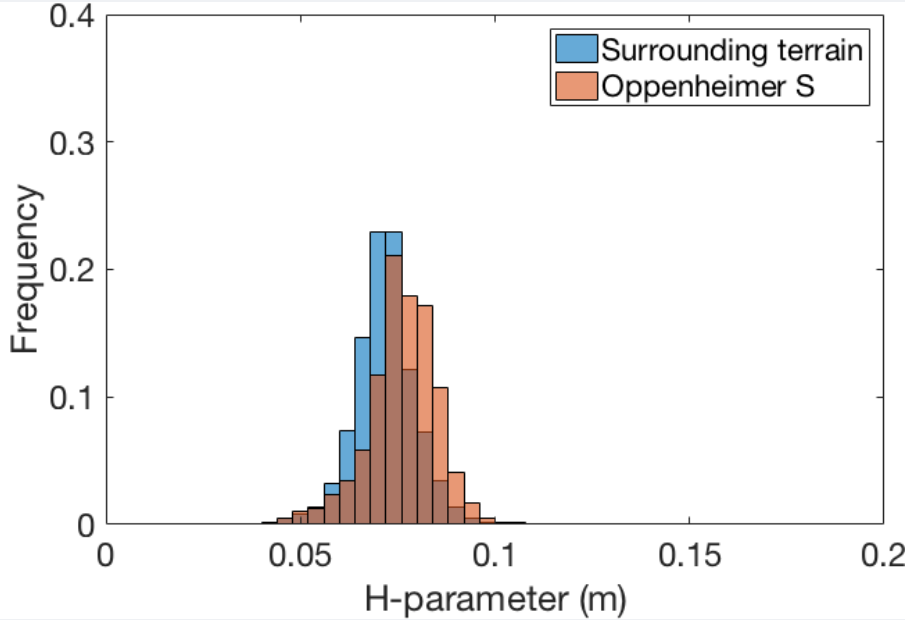
Localized Pyroclastic Deposits





Localized Pyroclastic Deposits





Localized Pyroclastic Deposits

Lack of thermal inertia anomaly means:

a) Thin; easily punctured by impacts

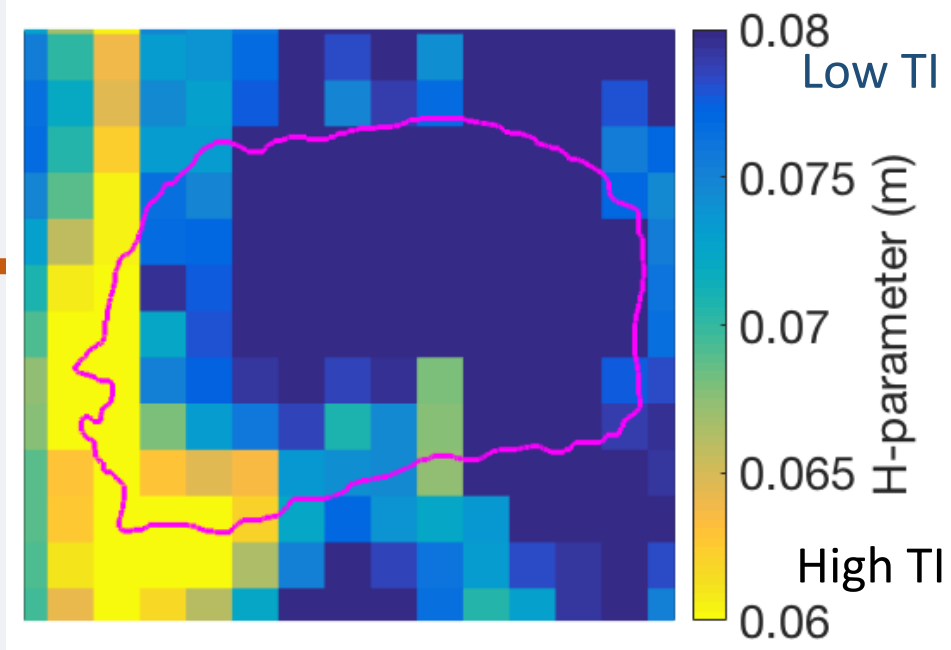
b) Small (in area); easily covered in rocks by nearby impacts or mass wasting of nearby slopes

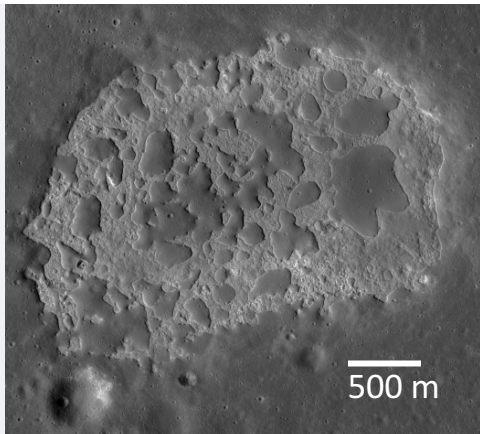
– or –

c) Original eruption incorporated a significant amount of country rock

Implications for Ina

- Magmatic foam
- Pyroclastic:
  a) Ina is younger than most localized deposits
  b) Deposit at Ina is thicker
  c) Deposit at Ina incorporated less country rock





Conclusions

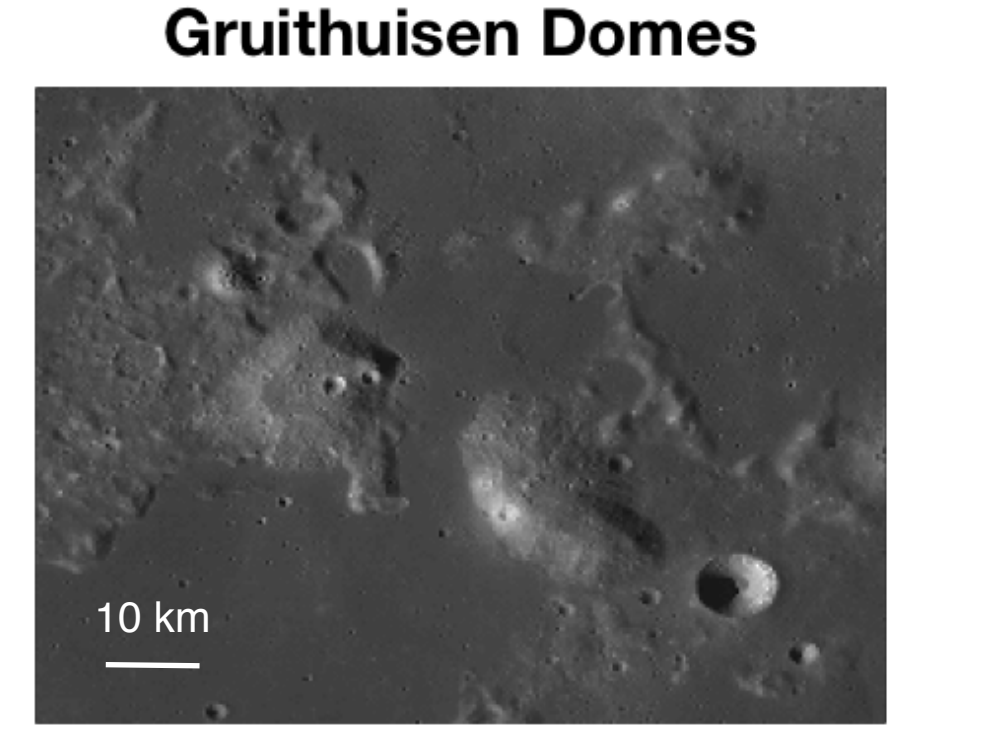
- Regional pyroclastic deposits have a lower thermal inertia than regolith
- Some localized pyroclastic deposits also have a lower thermal inertia than regolith, but some do not
  - Difficult to separate effects of eruption conditions from post emplacement modification
- Ina has a low thermal inertia consistent with either magmatic foam or young pyroclastic deposits

Back up slides

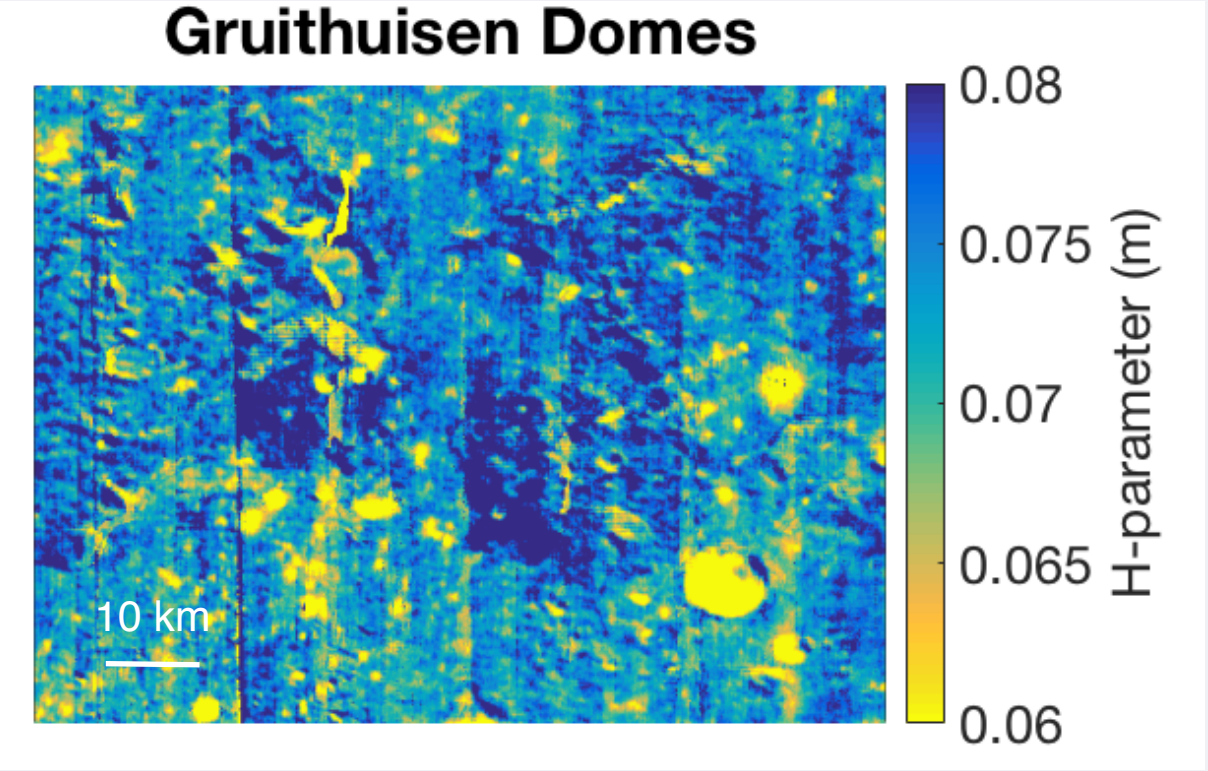
Lunar ‘Red Spots’

- Spectrally red
- Domes (with steep slopes and high albedos), smooth plains, shields, or rugged patches of highland material
- Generally pre-date mare volcanism; formed over shorter interval
- Created by viscous lava similar to terrestrial dacites, basaltic andesites, or rhyolites
- Some are highly silicic

Lunar Red Spots

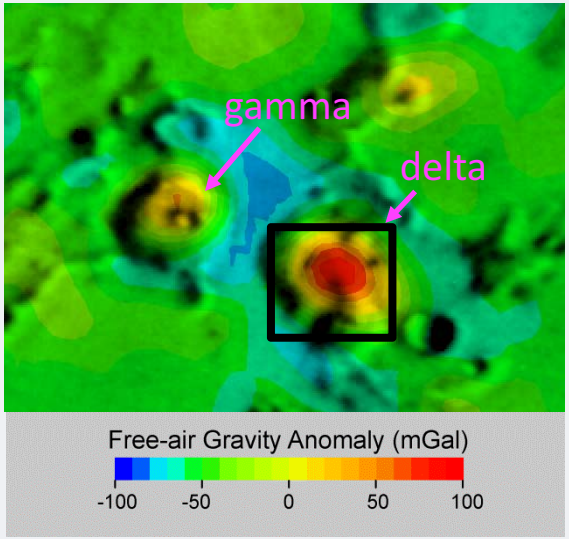


Lunar Red Spots



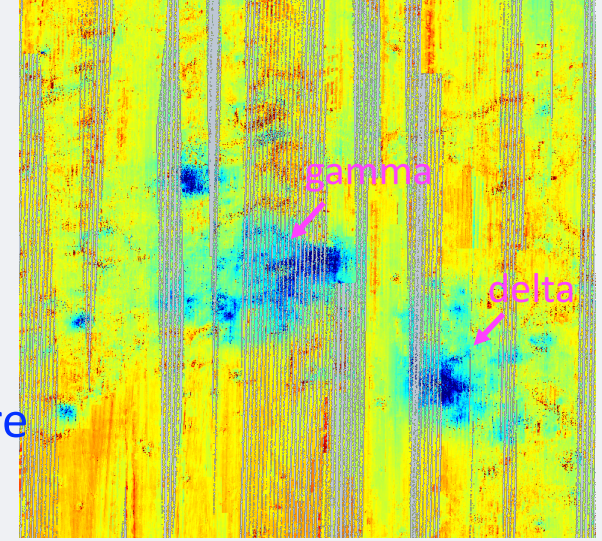
Free-air Gravity Anomaly (Kiefer et al., 2016):

Bulk density = 2150 kg m^{-3}

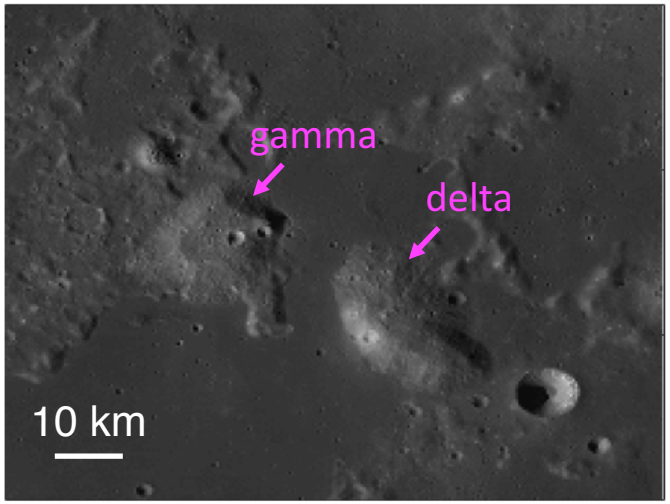


Christiansen Feature (CF) map:

Blue = more silicic



LROC WAC:



Thermal Inertia:

Blue = low TI